JACOBS

To: Maria Alliegro, NJDWSC
From: Al Hardesty, Jacobs
Date: 3/5/19
Subject: Review of OU-3 Site Related Groundwater Focused Feasibility Study
Project: Ringwood Mines/Landfill Superfund Site

Jacobs has reviewed the OU-3 Site Related Groundwater Focused Feasibility Study, Ringwood Mines/Landfill Superfund Site. Comparing our May 2017 Report, "Draft Report of the Potential Fate and Transport of Benzene, 1,4-Dioxane, Lead and Arsenic at the Ringwood Mines Superfund Site Relative to the Wanaque Reservoir" and our review of the feasibility study, we remain committed to these two recommendations: 1) Removal and treatment of the water in the PMP Air Shaft should be considered, and 2) Additional surface water sampling should be conducted on an ongoing basis to ensure 1,4 dioxane is not being detected at the discharge point from Ringwood Creek into the Wanaque Reservoir. Review comments have been organized based on the following categories: A) Items of High Importance, B) Disagreements with Technical Statements or Conclusions, C) Examples of Implied Bias for One Alternative Over Another, D) Further Clarification Needed, and E) General Comments.

A. ITEMS OF HIGH IMPORTANCE

1. **Section 6.2.2**, **Regarding the list of alternatives evaluated for remediation of the PMP Air Shaft**

Comment: Evacuation of water in the PMP air shaft with subsequent treatment is not identified as an alternative. This alternative would reduce the contaminant mass and reverse the groundwater gradient and would be the most protective of the downstream public water source. This would have a long-term effect of reducing the discharge of contaminated bedrock groundwater into the overburden groundwater and surface water. This alternative was not mentioned and should have been evaluated.

2. Section 7.2.1, page 70, second bullet, **"The absence of a discrete, defined source of COCs, including the potential for contributions from the overall mine workings, which are not the subject of remediation, as described in Section 3.2.2."**

Comment: Eliminating the overall mine workings from the remediation focus seems shortsighted. Contributions from the overall mine workings, specifically dioxane, will likely become the focus of remediation if dioxane should ever impact the Wanaque Reservoir. An additional study objective should have been to further sample more of the mine shaft network in an effort to determine if there is a discrete source that is impacting the PMP Air Shaft. This could be performed by drilling into known shafts and larger mining areas with directional controlled drilling equipment.

3. **Section 7.2.2, Alternative 2, Monitored Natural Attenuation (MNA), page 75, second bullet**

Comment: Assuring contact between contaminated groundwater and any injected remedy will be highly problematic in fractured bedrock. Such remedies may provide only a false sense of security (and additional expense) relative to MNA. Additionally, this section does not describe the frequency of surface water sampling or the methods. More frequent surface water monitoring is recommended, especially in light of the public water source located downstream. The use of automatic samplers which can collect a composite sample of several smaller

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samples over an extended period of time would be more useful than a few grab samples which only provide a snapshot in time. Contaminant flux often is greatest following storm events. The automatic samplers could be used to collect a series of grab samples before, during, and after a storm event to better evaluate contaminant flux. Jacobs recommends that weirs be installed on Park Brook and Ringwood Creek, with stilling wells, pressure transducers, and data loggers to monitor flow rates and allow more accurate assessments of contaminant flux to be developed.

4. Sections 7.3.2 Oxygen Diffusion in the PMP Air Shaft, page 80, regarding installation of a cap over the PMP Air Shaft

Comment: Cap closure should be designed to allow for other alternatives to be implemented in the event oxygen diffusion is not effective or in the event downstream contaminant migration worsens. Other means of access to the air shaft may be needed.

5. Sections 7.3.3 Treatment / Closure of the PMP Air Shaft

Comment: This alternative would have little long-term effect on the overall migration of contaminants out of the mine shaft system. It would be very shortsighted to assume that dioxane contamination in mine water is limited to the PMP Air Shaft. This alternative would permanently remove a major access point to the overall mine workings should other alternatives be needed in the event of contaminant migration worsening.

B. DISAGREEMENTS WITH TECHNICAL STATEMENTS OR CONCLUSIONS

6. Section 6.2.1, first paragraph – "The prior remediation activities at the Site, the OU2 remedial actions for the Land ACs (PMP Area, CMP Area, and OCDA), the removal actions, and the current site characterization data have not identified a discrete source for the residual VOC and SVOC concentrations in groundwater within the PMP Area and/or within the PMP Air Shaft or associated mine workings, including the Site-specific COCs of benzene, chloroethane, 1,4-dioxane, lead, and arsenic. In the absence of a specific source of these COC concentrations within the PMP or PMP Air Shaft a remedial action to target an actual source cannot be designed or implemented and, therefore, such an approach is infeasible."

Comment: Based on a review of the data and the site conceptual model, the logical conclusion is that the source of the dioxane lies in the overall mine workings and is migrating into the surrounding fractured bedrock. This conclusion is based on the fact that the highest concentrations of dioxane are found in the PMP Air Shaft at depths greater than 100 feet. Since bedrock groundwater has an upward flow gradient it would not be feasible for contaminants to have migrated downward from the surface. The contaminants had to be introduced at depth. The only viable pathway is through the overall mine workings. Granted there may not be a discrete source within the overall mine workings, diffuse contamination within the underground mine workings themselves may be the source for the COCs.

Recommendation: Sampling of mine water at various locations should be considered to further delineate mine water concentrations. Mapping of these concentrations would be helpful in determining if there is a discrete source or proving the fundamental overarching assumption that there is no discrete source.

7. Section 6.2.1.6, Groundwater Extraction, Treatment, and Discharge, first bullet, page 48, "Under existing conditions, there is no significant human health or ecological risk

associated with groundwater or surface water at the Site and no risk to any downgradient receptor, including the Wanaque Reservoir or the Borough's public water supply wells."

Comment: Jacobs disagrees with this statement. Granted administrative measures, such as instituting a groundwater classification exception area and well restriction area, could be implemented to eliminate the pathway for human consumption of groundwater which is above the USEPA acceptable cancer risk range, there is inherent risk of a detection of dioxane in Ringwood Creek at the discharge point into Wanaque Reservoir. The word "risk" refers to both the likelihood of a certain event happening and the consequence if that event occurs; in this case the event is the detection of dioxane in Ringwood Creek at the discharge point into Wanaque Reservoir. The likelihood of dioxane being detected in Ringwood Creek is low to moderate. This likelihood may increase during dry seasons of the year when there is less available surface water to dilute the discharge of groundwater into Park Brook. This possibility should be evaluated with a more intensive surface water sampling program. The consequence of dioxane being detected in Ringwood Creek at the discharge point into Wanaque Reservoir is extremely high. Pressure from the public could lead to the loss of a major drinking water source for 3 million people. Based on the likelihood and consequences, the risk is moderately low to moderate.

8. Section 6.2.2.2, Oxygen Diffusion via Chemical Addition in the PMP Air Shaft, Page 55, first bullet, Section 6.2.2.3 In-Situ Chemical Oxidation in the PMP Air Shaft, page 57, first bullet, Section 6.2.2.4, Biosparging of the PMP Air Shaft, page 59, first bullet, "COC concentrations in mine water stored within the PMP Air Shaft do not pose any significant risk to human health or the environment, and treatment of mine water within the PMP Air Shaft would have a negligible effect on meeting long-term groundwater quality objectives since the data indicate decreasing concentrations in the downgradient direction beyond the PMP Air Shaft under existing preremediation conditions."

Comment: These waters do pose a problem, because the water in the mine shafts is clearly the source of contamination that has migrated into the surrounding bedrock groundwater and has begun discharging into the surface water. See comment 7 above.

C. EXAMPLES OF BIAS

Although the Feasibility Study does not make any recommendations as to the preferred alternative, there is a perceived bias in favor of Alternative 3, Enhanced MNA Treatment Barrier. There are numerous places where negative aspects are used to eliminate other alternatives from consideration. These same negative aspects would also apply to Alternative 3, but are not addressed. These comments are not intended to argue for the other alternatives, just to illustrate the perceived bias. These observations are provided below.

9. Section 6.2.1.4, In-Situ Chemical Oxidation, page 43, last paragraph continuing onto page 44 – "Capital costs would be moderate for this alternative. The O&M costs would be high in the long-term due to the need for multiple injections given the competitive oxidant consumption issues noted above coupled with the difficulty in delivering the oxidant and ensuring radial distribution of the oxidant in the fractured bedrock."

Comment: This alternative assumes injection into fractured bedrock, when the prior alternative (Enhanced MNA Treatment Barrier) focused the oxygen ports in the overburden, citing that adequate coverage in the fractured bedrock would be impossible. This alternative should assume the same approach of focusing on the overburden groundwater.

10. Section 6.2.1.5, Air Sparge / Soil Vapor Extraction, page 45, last sentence, "Sparge points could effectively target more permeable zones; however, some of the residual COC mass is likely entrained/adsorbed in the lower permeability matrices of the overburden itself, which are not transmitting water."

Comment: This condition also applies to the previous two alternatives, Enhanced MNA Treatment Barrier and In-situ Chemical Oxidation, but was not addressed.

11. Section 6.2.1.5, Air Sparge / Soil Vapor Extraction (SVE), page 46, second paragraph, "The capital cost for AS/SVE would be moderate to high due to the need for multiple injection wells."

Comment: The proposed well spacing is not addressed for Air Sparging / SVE because the alternative is not carried forward, but this negative aspect also applies to Alternative 3, which requires injection wells every 20 feet. This is not initially addressed for Alternative 3.

12. Section 6.2.1.5, Air Sparge / Soil Vapor Extraction, page 46, first bullet – "The technical difficulty and questionable ability to create and sustain a continuous vertical curtain of sparged water within the PMP Area due to the significant heterogeneity of the overburden geology within and immediately downgradient of the PMP Area."

Comment: This same issue would apply to Alternative 3. It would be equally difficult to create a continuous curtain of oxygenated groundwater, but this was not addressed.

D. FURTHER CLARIFICATION NEEDED

13. Section 6.2.1, second paragraph – "In addition, the abundance of decaying organic material within the PMP as well as within the PMP Air Shaft, including wood and debris, tree limbs, leaves, etc., represent competitive "sinks" that would diminish the effectiveness of any active in-situ remedial action technique designed to come in contact with the COC mass that may be causing the concentrations reported in the PMP Area groundwater."

Comment: Descriptions of this material were not provided in any of the site background or characterization study sections preceding Section 6. Since this is a strong argument against one of the alternatives, additional detail on the nature and abundance of this material should be provided, including how it is known that these materials are present in the air shaft.

E. GENERAL COMMENTS

14. Section 6.2.1.3, MNA Treatment Barrier

Comment: The use of the word "barrier" is misleading. This alternative does not create a barrier to prevent contamination from migrating downgradient. It is designed to enhance natural attenuation and reduce downgradient migration. The term "perimeter treatment" would be more appropriate.

15. Section 6.2.2, PMP Air Shaft, page 51, second paragraph, "If there was a discrete source within the Air Shaft, higher dissolved phase concentrations would be expected."

Comment: Higher concentrations elsewhere in the overall mine workings may exist but remain unproven.

16. Section 7.2.2, Description of Alternative 2 MNA – regarding placement of sentinel wells.

Comment: The hydrogeology section states the following: "the lack of yield from the area-specific monitoring wells indicates that fractures within the crystalline bedrock have very limited transmissivity and/or connectivity." Because of the nature of a fractured flow system the likelihood of observing contaminant flux from the site at any specific bedrock sentinel well is low. The likelihood of missing a major pathway with higher concentrations and higher flux is high. This should be addressed. Since bedrock groundwater ultimately discharges to the overburden and eventually seeps into the surface water, the surface water monitoring is a better indicator. More frequent surface water monitoring might be more cost effective.

17. Section 7.2.3, MNA Treatment Barrier

Comment: A treatability study should be performed first if this alternative is selected. The study should include introduction of different media to determine the most effective material and should include observation at 5 and 10 feet from the well to determine actual effectiveness of oxygenating the groundwater. Additionally, the Jacobs May 2017 Report addressed the likelihood of iron fouling occurring with this alternative, which could also be evaluated during a treatability study.

18. General Comment Relative to Most Alternatives

Comment: Potential fouling and oxidant consumption by high levels of dissolved iron are only qualitatively acknowledged. Given the fundamental role of iron with respect to redox conditions, oxidant consumption, fouling, and sequestration of arsenic, its geochemistry merits more quantitative evaluation.

19. Modeling Throughout Document

Comment: Because the monitoring record for 1,4-dioxane goes back only to 2015, groundwater flow modeling would be an essential line of evidence to ascertain whether the observed contaminant distribution might still be expanding, is at steady-state, or might be contracting. Additional information should be provided on the modeling.

20. Pump and Treat

Comment: Efficacy arguments regarding pump-and-treat options seem unduly pessimistic. Induced cones of depression should propagate throughout the fractured bedrock system and capture migrating contaminants. A challenge facing extraction wells is the interception of significant fractures during installation.